

# Commission 4: Ephemerides

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## 1. Jet Propulsion Laboratory, Caltech, USA

JPL continues to be active in creating ephemerides in support of spacecraft navigation as well as various other functions. Many of the products are available on web sites:

(a) “Horizons”, the interactive web site, updated on an hourly basis, is located at <http://ssd.jpl.nasa.gov>. As of August, 2005, it contains orbital elements and ephemerides for the sun and 9 planets, 150 natural satellites (including the Moon), 291, 655 asteroids, 1631 comets, and 34 Spacecraft. Horizons uses the full precision of the JPL DE405.

(b) JPL’s Planetary and Lunar Ephemerides in “export” format are available via FTP from the Internet: <ftp://ssd.jpl.nasa.gov/pub/eph/export/> or on a CD-ROM: <http://www.willbell.com/software/jpl.htm> We advise to read the attached README.

(c) The observational data used in fitting the planetary ephemerides is available at the following web site, updated periodically: <http://ssd.jpl.nasa.gov/plan-eph-data/>

(d) SPICE Toolkit is a subroutine package for experienced programmers who write their own main driving programs for astrometrical computations. SPICE is available at <http://naif.jpl.nasa.gov/>. It contains a large library of subroutines useful in reading SPICE format ephemeris files (SPK) and in computing many solar system observation geometry parameters associated with the various JPL solar system missions. Available in Fortran, C, and IDL for most popular computing platforms.

## 2. US Naval Observatory, Astronomical Applications Department

This report covers activity in the Nautical Almanac Office (NAO) and its parent organization, the Astronomical Applications Department.

(a) Staff. S. Howard retired as Chief of the NAO in May 2003. S. Urban replaced her in June 2004. S. Dick and R. Miller served terms as Acting Chief in the interim. M. Efroimsky joined the staff on a permanent basis in March 2005. J. Hilton served as chair of the Division I Working Group on Precession and the Ecliptic and as a member of the Inter-Division Working Group on Cartographic Coordinates and Rotational Elements. Urban chaired the Commission 8 Working Group on the Densification of the Optical Reference Frame. G. Kaplan served as a member of the Division I Working Group on Nomenclature for Fundamental Astronomy. J. Bangert served as a member of the Standards of Fundamental Astronomy (SOFA) reviewing board.

(b) Publications. Regular publication of *The Astronomical Almanac* and *The Astronomical Almanac Online*, *The Nautical Almanac*, *The (U.S.) Air Almanac*, and *Astronomical Phenomena* continued as a joint activity between Her Majesty’s Nautical Almanac Office of the United Kingdom and the NAO. *The Astronomical Almanac* for 2006, released in January 2005, was the first edition to incorporate fully the resolutions on reference frames, Earth rotation models, and time scales adopted by the IAU in 1997

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and 2000. U.S. Naval Observatory Circular 179, *The IAU Resolutions on Astronomical Reference Systems, Time Scales, and Earth Rotation Models: Explanation and Implementation*, was in preparation and scheduled for release in late 2005.

(c) Software. A major upgrade of the *Multiyear Interactive Computer Almanac*, MICA version 2.0, was completed and released in July 2005. The software is available in two editions for computers running Microsoft Windows and Apple Mac OS operating systems. A new version of the Naval Observatory Vector Astrometry Subroutines (NOVAS) that implements the 1997 and 2000 IAU resolutions is under development, with release anticipated in late 2005 or early 2006. Use of the Astronomical Applications Department web site <http://aa.usno.navy.mil/> continued to grow during the reporting period. Usage varied from about 20,000 to 40,000 user sessions per day.

(d) Research program. An active research program in positional and dynamical astronomy is underway within the department. See <http://aa.usno.navy.mil/research/>.

### 3. Astronomical Institute, Czech Republic

The Institute, in close cooperation with the Observatory and Planetarium of Prague, issues every year an astronomical yearbook of about 250 pages for amateur astronomers “Hvězdářská ročenka” (in Czech), with a limited precision. The yearbook is based on the VSOP82 ephemerides and it contains the ephemerides of the Sun, Moon, planets and their satellites, asteroids, comets, meteoric streams and variable stars. Many phenomena (such as eclipses, occultations, conjunctions and oppositions etc...) are also included. All calculations are made at the Astronomical Institute, still in the ‘old’ system (i.e., using equinox, IAU1976 precession and IAU1980 nutation). We suppose to follow other ‘big’ ephemeris books such as *The Nautical Almanac*, *The Astronomical Almanac*, *Connaissance des Temps*, *Astronomicheskii Ezhegodnik* etc..., when they decide on the new format of published data. In addition, the prediction of lunar occultations is provided also for four Romanian observatories and published in Romanian astronomical yearbook.

### 4. National Astronomical Observatory (NAOJ), Japan

Annually the National Astronomical Observatory of Japan (NAOJ) publishes the “Calendar and Ephemeris”, a basic almanac designed for astronomical observers, teachers, and citizens. This work has been conducted by the ECO. The ECO has enhanced its web site (<http://www.nao.ac.jp/koyomi/>) with lots of useful interactive programs such as rising, setting, and transit of the Sun and the Moon. Topics from the “Calendar and Ephemeris” is also included in this site.

### 5. HM National Almanac Office, UK

HMNAO continues to operate under commercial conditions at the Rutherford Appleton Laboratory of the Council for the Central Laboratory of the Research Councils. It has undergone a review by the UK Ministry of Defense with a view to transferring the operation to the UK Hydrographic Office. The review has established a continuing requirement for the *Nautical Almanac*. Activity of HMNAO:

(a) Staff. C. Hohenkerk served as a member of the Division I Working Group on Nomenclature for Fundamental Astronomy and as a member of the Standards of Fundamental Astronomy (SOFA) reviewing board.

(b) Publications. Joint publications with the US Naval Observatory, *The Nautical Almanac*, *The Astronomical Almanac* and *Astronomical Phenomena*, have been produced

on schedule. Material in Section B of *The Astronomical Almanac 2006* has been produced in accordance with the recommendations of the IAU General Assemblies up to and including 2000. This includes the addition of new tables and explanatory material that describe the CIO-based method for calculating positions, which compliments the equinox-based material already present. Besselian and second order day numbers have been moved to *The Astronomical Almanac Online* web site. New material has been introduced into Section G including the ephemerides of 15 of the largest minor planets. Work on compact expressions for satellite positions has been completed and implemented in the satellite phenomena given in Section F. A new edition of *NavPac and Compact Data* for 2006–2010 has been published.

(c) Web site publishing. Material available on the web has been increased. Information on the transits of Venus 1000 CE to 2700 CE was provided in time for the 2004 transit and a new eclipse web site has been launched called “Eclipses Online” at <http://www.eclipse.org.uk> which provides information and local circumstance animations for solar and lunar eclipses in the interval 1501 CE to 2100 CE. HMNAO continues to provide information on request to the general public. A new web site is to be launched in conjunction with the Institute of Physics to gather data on the first sighting of the new crescent moon at <http://www.crescentmoonwatch.org>.

(d) Special services. HMNAO has continued to provide specialist services to those that need them e.g. analysis of photographic material for the Bloody Sunday Inquiry.

## 6. Institute of Applied Astronomy, Russia

(a) Fundamental ephemerides. Russian Astronomical Yearbook for 2006 is published with a number of improvements. Planetary and lunar ephemerides are based on the numerical model EPM2004, parameters of which are fitted to planet observations 1900–2004 of different types, and the lunar laser ranging measurements 1969–2003. The ephemerides are constructed by simultaneous numerical integrating the major planets, the Sun, the Moon (including lunar rotation) and 301 perturbing asteroids.

The published apparent places are calculated in the FK6/HIPPARCOS system applying IAU2000 nutation. Implementation of the IAU resolution concerning CIO is in progress. Detailed Explanatory Supplement to the Astronomical Yearbook is published (in Russian). Ephemerides for planetary configurations and occultations are updated and accessible in the Web site “[http://quasar/ipa.nw.ru/PAE/cp1251/rusnews.html](http://quasar.ipa.nw.ru/PAE/cp1251/rusnews.html)”

(b) Special ephemerides. Russian Nautical Yearbook for 2006 is published on the same new ephemeris base. Nautical Almanac for the two-year time span 2005–2006 is also issued. This version provides users with more information than the Nautical Yearbook keeping the same volume of the printed text.

(c) Software. Preparation of the ephemerides for publishing, as well as constructing the corresponding numerical dynamical models and fitting the ephemerides to observations are carried out in the framework of the universal program system ERA (Ephemerides for Research in Astronomy) based on a problem-oriented programming language SLON for Dynamical Astronomy and Astrometry. The DOS version of the system (with some useful applications) are available via anonymous FTP: “[quasar.ipa.nw.ru/incoming/era](http://quasar.ipa.nw.ru/incoming/era)”. It is implemented with new numerical model of rotation of the non-rigid Earth constructed by numerical integration and fitted to VLBI-based positions of Celestial Pole and UT for 1984–2005. Cross-platform Windows-Linux version is in progress. The polynomials presenting EPM2004 ephemerides are transformed for Fortran usage and available through anonymous FTP (with Fortran subroutines to evaluate the polynomials): “[quasar.ipa.nw.ru/incoming/EPM2004](http://quasar.ipa.nw.ru/incoming/EPM2004)”

## 7. IMCCE, Paris Observatory

During the 2003–2005 period, besides research activities which are not developed here, the ephemerides activities at Institut de Mécanique Céleste et de Calcul des Éphémérides (IMCCE) were focused on the tasks described hereafter. At first, in the frame of the mission related to the Bureau des longitudes, IMCCE continues the performing and publication of annual ephemerides. But several electronic works have also been performed, in particular with the aim to extend and improve the ephemerides web services. In 2003, W. Thuillot was designated as director of IMCCE for the 2003–2006 period and coordinated these works of the IMCCE staff:

(a) The “Éphémérides astronomiques – Connaissance des temps” gives high precision ephemerides. They are issued from the dynamical models developed at IMCCE (VSOP for the planets and the Sun, ELP for the Moon, G-5 for the Galilean satellites, TASS for the Saturnian satellites, GUST for the Uranian satellites). Since 2003, it includes now many scientific chapters which give fundamental informations on the reference systems, time scales, coordinates transformations, Earth rotation. These texts have been updated in 2004 and 2005 by their authors who are specialists in these fields. It should be noticed that the 2006 version, prepared in 2005, has a new format: tables of positions replace the Chebychev coefficients in the book. This former representation is only used by a new software named e-cdt which provides accurate and extended ephemerides on a CD-ROM together with the book. The new IAU resolutions are taken into account by the implementation of the IAU 2000 precession and IAU 2000A nutation models in 2004, the publication of the Earth Rotation Angle, equation of origins and CIP coordinates in 2005.

(b) Three booklets named “Suppléments à la Connaissance des Temps” have been published yearly. They provide ephemerides of natural satellites and are dedicated to the help of observers. The first one gives the phenomena of the Galilean satellites and their graphics configurations, the second one gives the graphic configuration of the Saturnian satellites and the third one gives ephemerides of several faint satellites.

(c) The “Guide de données astronomiques – Annuaire du Bureau des longitudes” has been published in close format than the previous years. It contains data on the calendars, the time scales and astronomical calculations. Tables give the Sun, Moon and planets coordinates, rise and set hours, the asteroids and comets coordinates, and data on the eclipses and some other astronomical phenomena. Since 2003, this book contains a thematic notebook.

(d) “Éphémérides Nautiques” have been published in the similar format than the previous years.

(e) A new format of the IMCCE web server at [www.imcce.fr](http://www.imcce.fr) including a wide ephemerides service has been set up. Ephemerides using the full precision theories and numerical models for all the planets, a large number of natural satellites, all the known asteroids and comets are given there. Besides several kind of coordinates, topocentric coordinates can be computed on this server. Phenomena and mutual phenomena of the natural satellites are also available.

(f) Predictions of the phenomena of the Galilean satellites and graphic configurations have been yearly computed and sent for publication in a dozen of foreign almanacs.